NATIONAL R&D TRENDS

In the mid- to late 1990s, R&D performance in the United States surged. In real terms (constant or inflation-adjusted dollars), total R&D performance grew 40.5 percent between 1994 and 2000 at an average annual real growth rate of 5.8 percent over the period (figure 1). NSF data indicate that this growth rate was not sustained in subsequent years. After adjusting for inflation, total R&D increased 1 percent between 2000 and 2001, declined a marginal amount between 2001 and 2002, and increased 1 percent between 2002 and 2003. Total 2003 R&D performance in the United States is projected to be $283.8 billion, up from an estimated $276.4 billion in 2002 and $274.2 billion in 2001. (See sidebar, "Definitions of R&D.")

Definitions of R&D

The National Science Foundation (NSF) uses the following definitions in its research and development surveys. They have been in place for several decades and generally are consistent with international definitions.

R&D. According to international guidelines for conducting research and development (R&D) surveys, R&D, also called research and experimental development, comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

Basic research. The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific immediate commercial objectives, although it may be performed in fields of present or potential commercial interest.

Applied research. The objective of applied research is to gain the knowledge or understanding to meet a specific, recognized need. In industry, applied research includes investigations to discover new scientific knowledge that hasspecific commercial objectives with respect to products, processes, or services.

Development. Development is the systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.

R&D plant. R&D plant includes the acquisition of, construction of, major repairs to, or alterations in structures, works, equipment, facilities, or land for use in R&D activities.

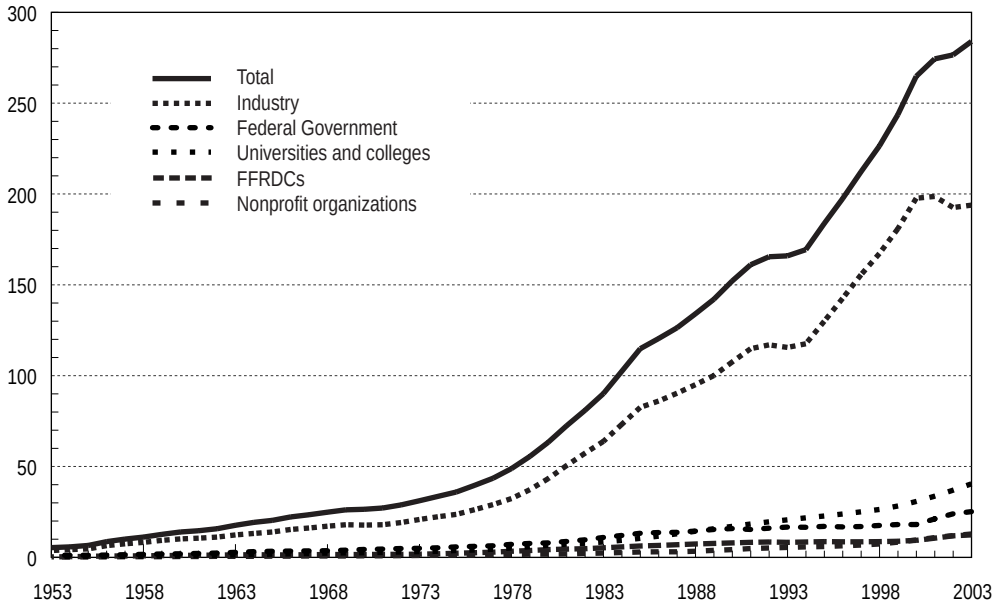
Budget authority. Budget authority is the authority provided by Federal law to incur financial obligations that will result in outlays.

Obligations. Federal obligations represent the dollar amounts for orders placed, contracts awarded, services received, and similar transactions during a given period, regardless of when funds were appropriated or payment was required.

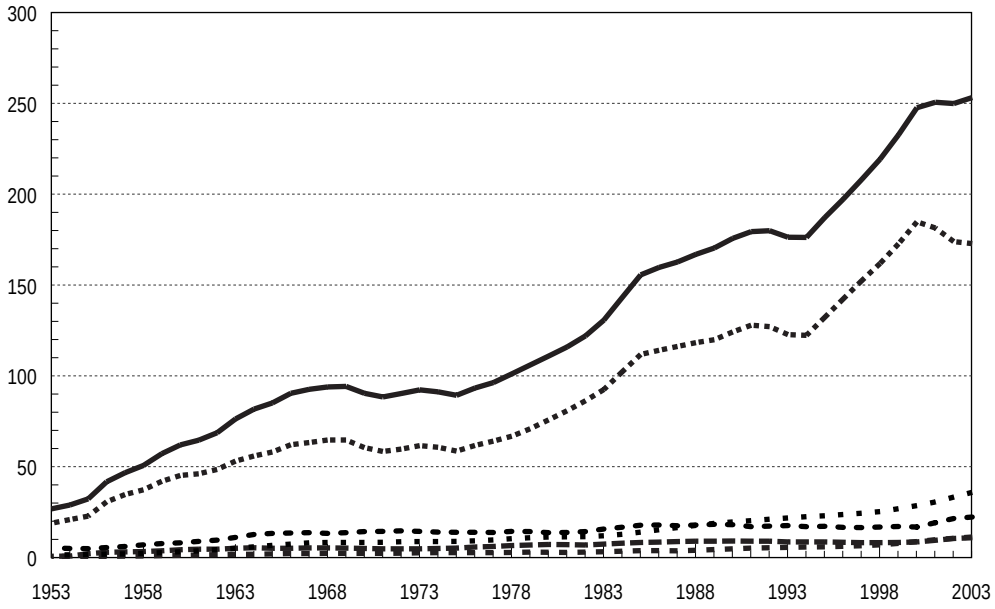
Outlays. Federal outlays represent the dollar amounts for checks issued and cash payments made during a given period, regardless of when funds were appropriated or obligated.

FIGURE 1. U.S. research and development performance, by performing sector: 1953–2003

Billions of current dollars



Billions of constant 1996 dollars



FFRDC federally funded research and development center

SOURCE: National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources,* annual series. See appendix tables B-1 and B-21.

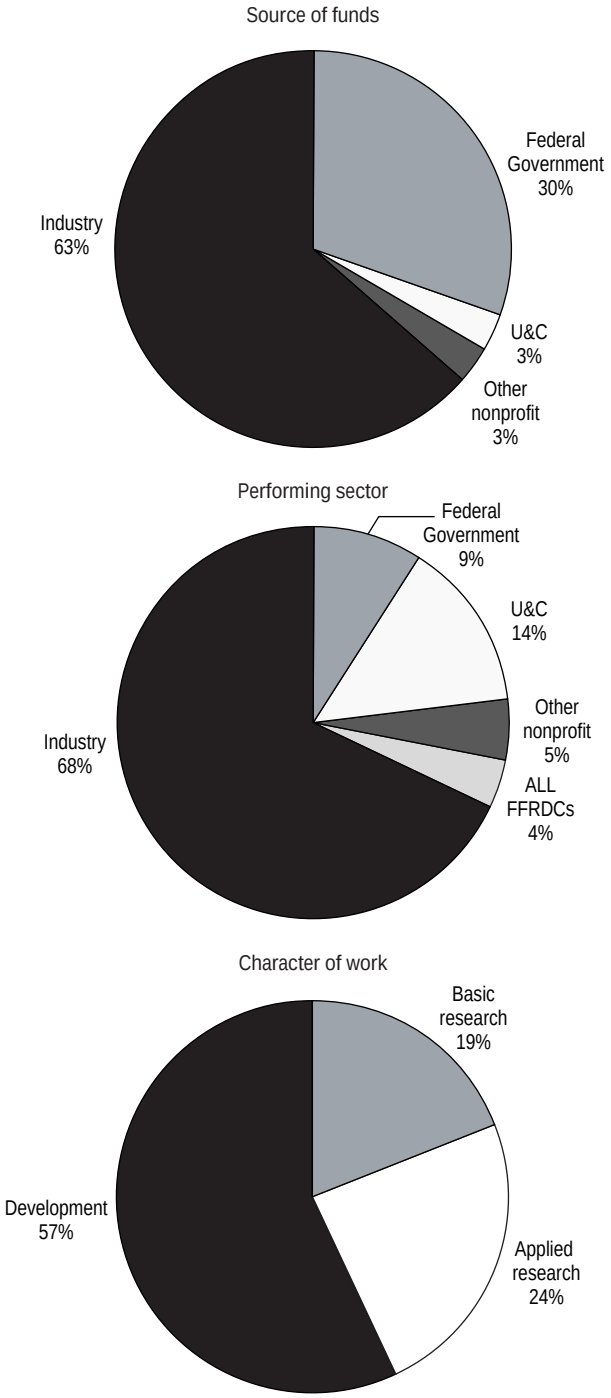
In comparison, gross domestic product (GDP), the main measure of the nation's total economic activity, grew in real terms by 3.8 percent per year between 1994 and 2000. R&D performance as a proportion of GDP rose from 2.40 percent in 1994 to 2.69 percent in 2000 as growth in R&D outpaced the growth of the overall economy. The ratio of R&D to GDP peaked in 2001 at 2.72 percent as the rate of economic growth from the late 1990s slowed. In the subsequent years, total R&D grew at a slower pace than the overall economy, resulting in R&D to GDP ratios of 2.65 percent in 2002 and 2.61 percent in 2003.[2]

Organizations that perform R&D often receive outside funding; conversely, organizations that fund R&D do not always perform all the R&D themselves. Therefore, it is useful to analyze R&D expenditure data in terms of who performed the R&D and who funded it.

Industry performs most of the nation's R&D and accounted for a projected 68.3 percent of total R&D performance in 2003.[3] Universities and colleges accounted for a projected 14.2 percent of national R&D performance in 2003, followed by the Federal Government (8.8 percent) and nonprofit institutions (4.5 percent).[4] All federally funded research and development centers (FFRDCs) combined are projected to have performed 4.3 percent of U.S. total R&D in 2003 (figures 1 and 2; table 1).

Private industry is also the largest source of R&D funding in the United States and provided a projected

FIGURE 2. Shares of U.S. research and development expenditures, by source of funds, performing sector, and character of work: 2003



FFRDC federally funded research and development center
U&C universities and colleges

NOTES: Figures are rounded to nearest whole number. National research and development expenditures were an estimated $284 billion in 2003.

SOURCE: National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources,* annual series. See appendix tables B-1, B-3, B-5, and B-7.

[2]The estimated U.S. gross domestic product (GDP) for 2001, 2002, and 2003 in constant 1996 dollars is $9,215 billion, $9,440 billion, and $9,710 billion, respectively. See appendix table B-9.

[3]Unless otherwise noted, whenever a sector is mentioned, federally funded research and development centers (FFRDCs) are excluded. FFRDCs are R&D-performing organizations that are exclusively or substantially financed by the Federal Government either to meet a particular R&D objective or, in some instances, to provide major facilities at universities for research and associated training purposes. Each FFRDC is administered either by an industrial firm, a university, or a nonprofit institution. In some of the statistics provided in this report, FFRDCs are included as part of the sector that administers them and are so noted. In particular, statistics on the industrial sector often include industry-administered FFRDCs because for some of the statistics from the National Science Foundation (NSF) Survey of Industrial Research and Development before 2001 the FFRDC component cannot be reported separately.

[4]Recent methodological improvements have resulted in revisions from the amounts previously reported for total academic R&D expenditures. For more information, see M. Machen and B. Shackelford, *Academic R&D Spending Maintains Growth From All Major Sources in FY 2001,* NSF InfoBrief (Arlington, VA, 2003).

TABLE 1. U.S. research and development expenditures, by character of work, performing sector, and source of funds: 2003 (Projected)

Performing sector	Source of funds (millions of dollars)					Percent distribution of total expenditures
	Total	Industry	Federal Government	U&C	Other nonprofit institutions	
R&D	283,795	179,615	85,280	10,654	8,247	100.0
Industry	193,729	176,415	17,314	—	—	68.3
Industry-administered FFRDCs	2,383	—	2,383	—	—	0.8
Federal Government	24,959	—	24,959	—	—	8.8
U&C	40,262	2,123	24,499	10,654	2,986	14.2
U&C-administered FFRDCs	7,421	—	7,421	—	—	2.6
Other nonprofit institutions	12,661	1,077	6,323	—	5,261	4.5
Nonprofit-administered FFRDCs	2,381	—	2,381	—	—	0.8
Percent distribution by source	100.0	63.3	30.0	3.8	2.9	na
Basic research	54,103	9,020	32,712	7,380	4,990	100.0
Industry	7,725	6,952	773	—	—	14.3
Industry-administered FFRDCs	651	—	651	—	—	1.2
Federal Government	4,463	—	4,463	—	—	8.2
U&C	29,941	1,470	19,022	7,380	2,069	55.3
U&C-administered FFRDCs	3,625	—	3,625	—	—	6.7
Other nonprofit institutions	6,709	598	3,190	—	2,921	12.4
Nonprofit-administered FFRDCs	988	—	988	—	—	1.8
Percent distribution by source	100.0	16.7	60.5	13.6	9.2	na
Applied research	67,780	39,551	23,458	2,685	2,086	100.0
Industry	42,434	38,743	3,691	—	—	62.6
Industry-administered FFRDCs	1,040	—	1,040	—	—	1.5
Federal Government	8,837	—	8,837	—	—	13.0
U&C	8,927	535	4,954	2,685	753	13.2
U&C-administered FFRDCs	1,968	—	1,968	—	—	2.9
Other nonprofit institutions	4,215	273	2,609	—	1,333	6.2
Nonprofit-administered FFRDCs	359	—	359	—	—	0.5
Percent distribution by source	100.0	58.4	34.6	4.0	3.1	na
Development	161,911	131,042	29,109	589	1,171	100.0
Industry	143,569	130,719	12,850	—	—	88.7
Industry-administered FFRDCs	692	—	692	—	—	0.4
Federal Government	11,658	—	11,658	—	—	7.2
U&C	1,394	117	523	589	165	0.9
U&C-administered FFRDCs	1,828	—	1,828	—	—	1.1
Other nonprofit institutions	1,736	206	524	—	1,006	1.1
Nonprofit-administered FFRDCs	1,034	—	1,034	—	—	0.6
Percent distribution by source	100.0	80.9	18.0	0.4	0.7	na

na not applicable
— less than $0.5 million or less than 0.5 percent
FFRDC federally funded research and development center
R&D research and development
U&C universities and colleges

NOTES: State and local government support to industry is included in industry support for industry performance. State and local government support to U&C ($2,710 million in total R&D) is included in U&C support for U&C performance.

SOURCE: National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources* (Arlington, VA, annual series). See appendix tables B-1, B-3, B-5, and B-7.

63.3 percent ($179.6 billion) of total R&D funding in 2003. Most of these funds (98.2 percent) flowed to industrial performers of R&D. The Federal Government provided the second largest share of R&D funding, 30.0 percent ($85.3 billion), with only 43.6 percent of these funds financing Federal labs and FFRDCs. The other sectors of the economy (i.e., state governments, universities and colleges, and nonprofit institutions) contributed the remaining 6.7 percent ($18.9 billion) (table 1).

Trends in R&D Performance

U.S. R&D has experienced largely uninterrupted growth over the past 50 years (figure 1). U.S. R&D performance grew in terms of current dollars each year between 1953 and 2003, even in the early 1990s when both Federal and industrial R&D funding slowed significantly[5] (figure 3). In the mid-1990s, substantial increases in industrial R&D, most notably in the computer and other information technology (IT) sectors and in small R&D-performing firms, ended a brief slowdown in national R&D growth.[6] Between 1994 and 2000, an 8.8 percent real annual growth rate in industrial support for R&D overshadowed a slight decline (–0.3 percent per year) in real Federal R&D support, resulting in overall real annual growth of 5.8 percent in U.S. R&D.

More recently, the growth of R&D investment in the United States has slowed. Preliminary data and projections indicate that although total R&D expenditures continued to rise through 2003 in current dollars, industrial R&D, which fueled the growth over the prior period, declined in 2002. This has occurred only two other times in the past 50 years—in 1970 and 1993. The business activities of many R&D-performing firms were curtailed following the stock market decline and subsequent economic slowdown of 2001 and 2002. The same sectors that saw impressive increases in the late 1990s experienced declines in sales, share prices, and R&D investment at the beginning of this decade. Economic indicators suggest modest growth in current dollar industrial R&D in 2003.

[5]These findings are based on performer-reported R&D levels. In recent years, substantial differences have been detected in data on federally financed R&D as reported by Federal funding agencies and by performers of the work (most notably, industrial firms and universities). This divergence in R&D totals is discussed in the sidebar "Tracking R&D: Gap Between Performer- and Source-Reported Expenditures."

[6]For most manufacturing industries, the U.S. Small Business Administration defines *small firm* as one with 500 or fewer employees. The share of company-financed R&D performed by these firms grew from 10 percent in 1990 to a peak of 20 percent in 1999.

Trends in Federal R&D Funding

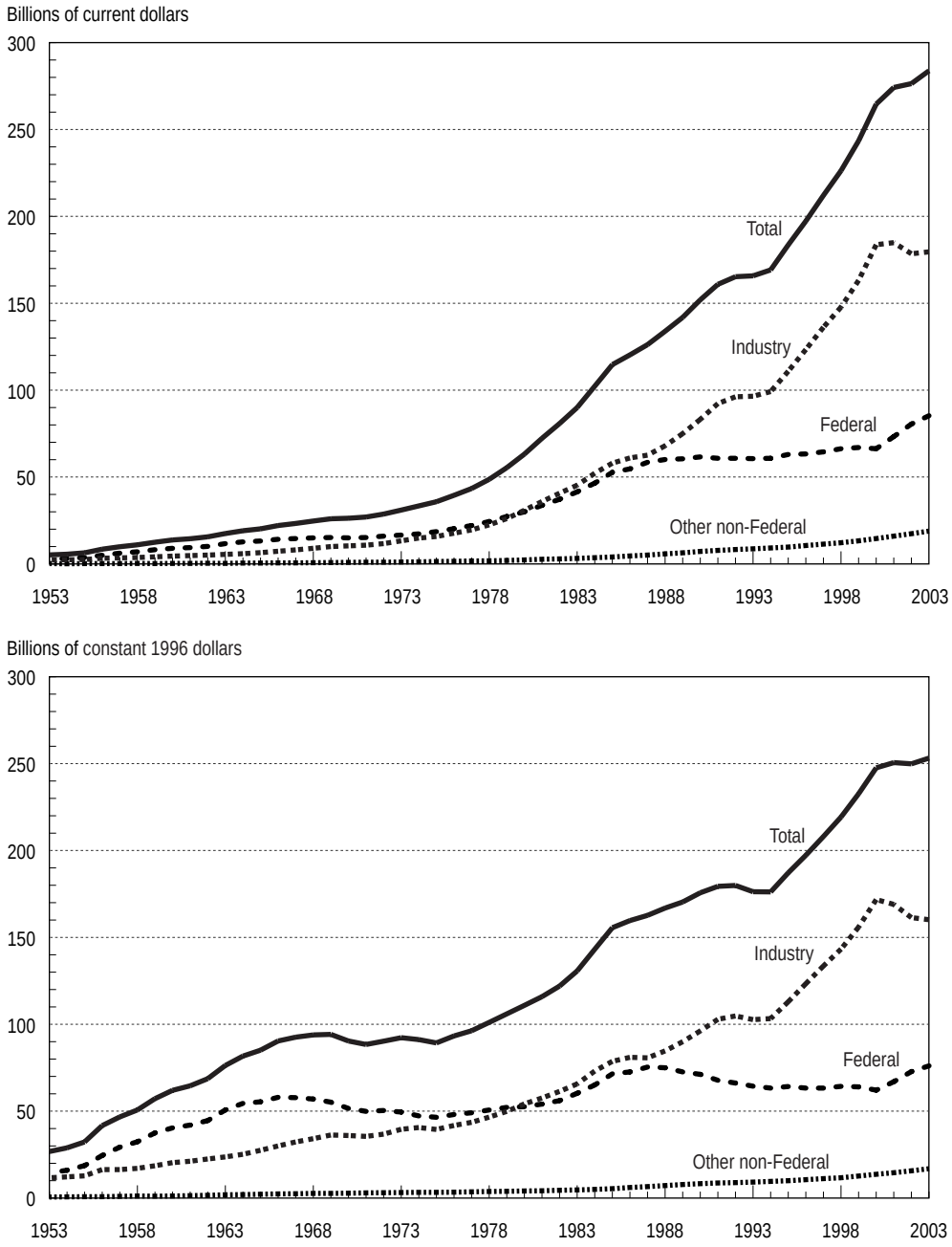
Increases in Federal R&D investment, particularly in the areas of defense, health, and counterterrorism, helped to offset languid industrial R&D performance in 2001, 2002, and 2003. These increases also reversed a decades-long trend in the shrinking share of Federal R&D funding as a percentage of the nation's total R&D (figure 4).

The Federal Government was once the main source of the nation's R&D funds, funding as much as 66.8 percent of all U.S. R&D in 1964. The Federal share first fell below 50 percent in 1979, and after 1987 it fell steadily, dropping from 46.3 percent in that year to 25.1 percent in 2000—the lowest it has ever been since the start of the time series in 1953. This sharp decline in the Federal Government share, however, should not be misinterpreted as a drastic decline in the actual amount of R&D funded (figure 3). Adjusting for inflation, Federal support decreased 18 percent from 1987 to 2000, although in nominal terms, Federal support grew from $58.5 billion to $66.3 billion during that period. Growth in industrial funding generally outpaced growth in Federal support, leading to the decline in Federal support as a proportion of the national total. The slowdown of industry's investment in R&D, as well as increases in Federal R&D funding in recent years, reversed this trend. Thus in 2003, the Federal share of R&D funding is projected to have grown to 30.0 percent.

Federal R&D Funding by National Objective

In 2003 the Federal Government funded over twice as much R&D as that performed by Federal agencies and FFRDCs. This support is projected to be $85.3 billion, reflecting a 7.0 percent average real increase per year since 2000. This funding supports a wide range of national objectives (also termed *budget functions*); is administered by many Federal agencies; and flows to R&D performers in all sectors, from industry to universities and colleges and to nonprofit organizations.

FIGURE 3. U.S. research and development funding, by source of funds: 1953–2003



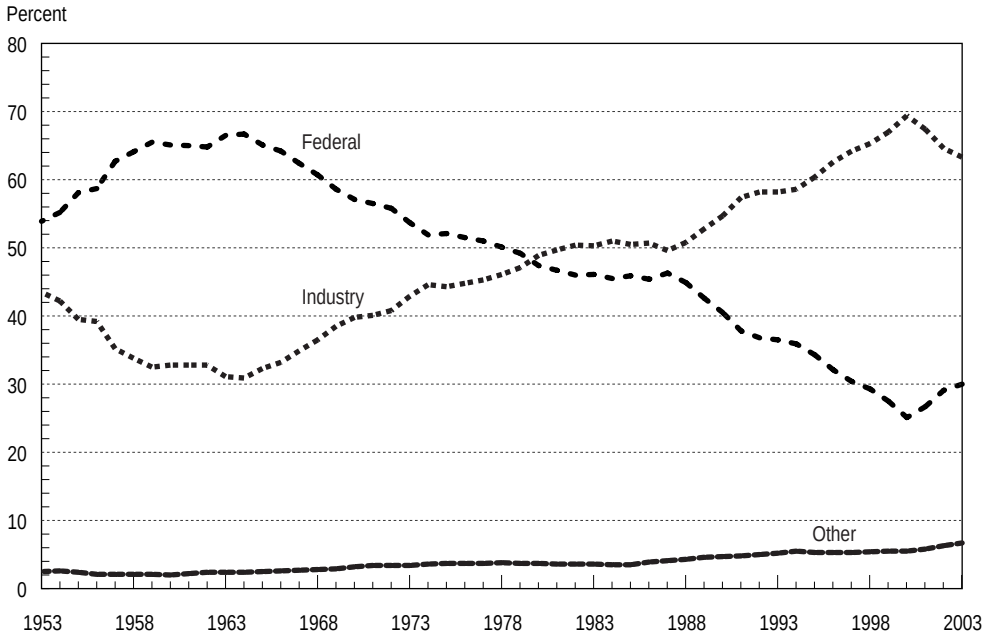
SOURCE: National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources,* annual series. See appendix tables B-2 and B-22.

Defense-Related R&D. Defense-related R&D, as a proportion of the nation's total R&D, has shifted substantially. From 53.6 percent in 1959, it declined to a relative low of 24.2 percent in 1980, climbed to 31.7 percent by 1987, and, coinciding with the end of the cold war, fell substantially afterward, reaching a low of 13.5 percent in 2000 (figure 5).[7] Despite this dramatic decline relative to nondefense R&D, the absolute level of defense R&D in 2000 still exceeded that in any year from 1953 to 1982, after adjusting for inflation. In 2001, 2002, and 2003 defense-related R&D as a share of U.S. R&D began to grow again, reaching a projected 16.2 percent of the nation's total R&D in 2003.

In 1980 the Federal budget authority for defense-related R&D was roughly equal to that for nondefense R&D[8] (figure 6). Although the amount of defense-related R&D has fluctuated based on changing national security concerns over the past 20 years, nondefense R&D has exhibited fairly steady growth since 1983. For FY 2001 the budget authorities for defense R&D and for nondefense R&D had nearly reached parity at $45.7 and $41.0 billion, respectively. The terrorist attacks of September 11, 2001, dramatically reversed this trend and in the proposed FY 2004 budget, $66.8 billion is slated for defense-related R&D, and $51.2 billion is reserved for nondefense R&D. (See sidebar, "Federal R&D for Countering Terrorism.") These amounts reflect increases of 46.2 percent in defense-related R&D and 24.7 percent in nondefense R&D over the FY 2001 levels.

Civilian-Related R&D. R&D accounts for 13.4 percent of the FY 2004 Federal nondefense discretionary budget authority of $383.0 billion.[9] R&D is more prominent among defense activities, accounting for 16.7 percent of the $399.2 billion defense discretionary budget authority in FY 2004. However, over 90 percent of Federal basic research funding is for nondefense functions, accounting for a large part of the budgets of agencies with nondefense missions such as general science (NSF), health [National Institutes of Health (NIH)], and space research and technology [National Aeronautics and Space Administration (NASA)] (table 2, appendix table B-11). Because many different agencies

FIGURE 4. U.S. research and development expenditures, by source of funds: 1953–2003



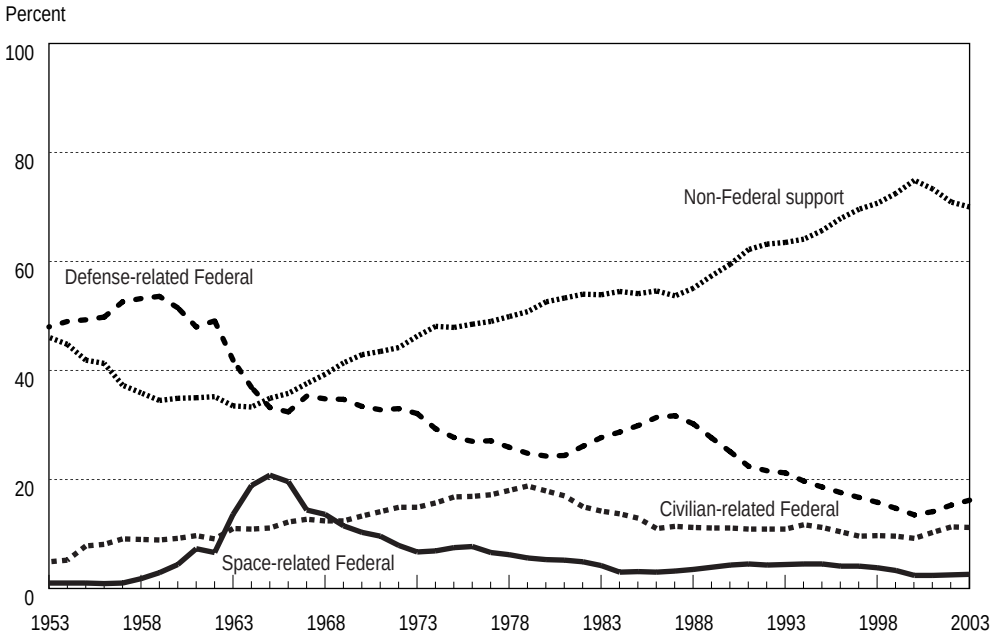
SOURCE: National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources,* annual series. See appendix table B-2.

[7]These shares represent a distribution of performer-reported R&D data. They are distinct from the budget authority shares reported subsequently, which are based on the various functional categories constituting the Federal budget.

[8]R&D budget authority data represent a distribution of Federal source-reported data as opposed to performer-reported data.

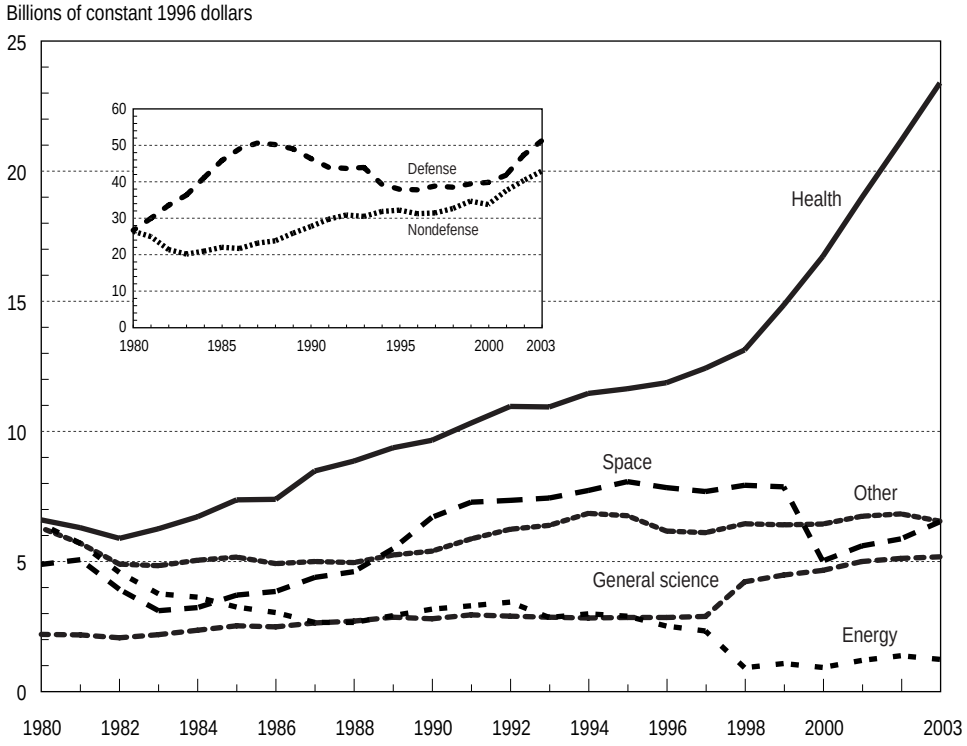
[9]Most of the $2.2 trillion Federal budget is reserved for mandatory items such as Social Security, Medicare, pension payments, and payments on the national debt. See appendix table B-13 for historical data on Federal outlays and R&D.

FIGURE 5. Federal and non-Federal share of U.S. research and development: 1953–2003



SOURCE: National Science Foundation, Division of Science Resources Statistics, unpublished tabulations, 2003. See appendix table B-10.

FIGURE 6. Federal research and development budget authority, by budget function: FY 1980–2003



NOTES: "Other" includes all nondefense functions not separately graphed, such as agriculture and transportation. 1998 increase in general science and decrease in energy and 2000 decrease in space were results of reclassification.

SOURCE: National Science Foundation, Division of Science Resources Statistics, *Federal R&D Funding by Budget Function: Fiscal Years 2001–2003* (Arlington, VA, 2002).

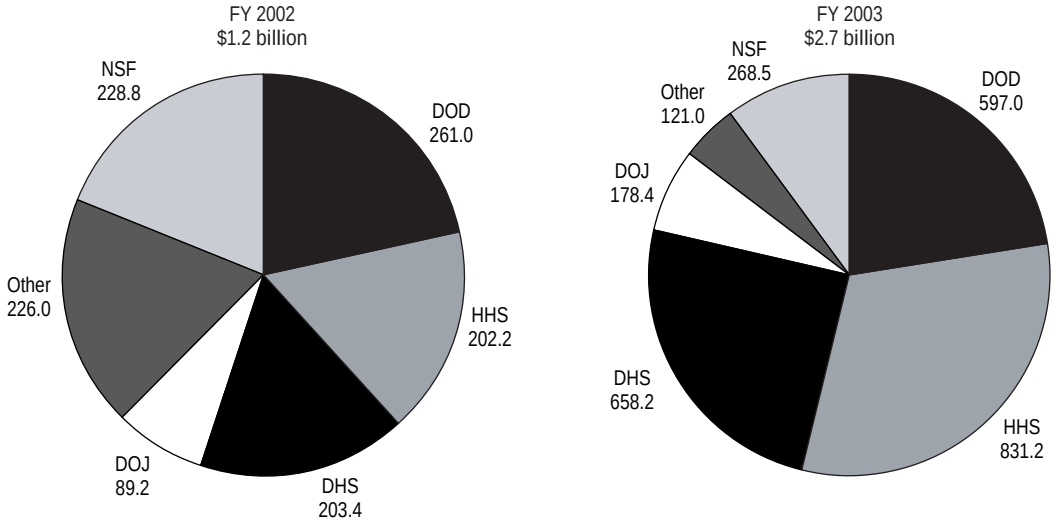
Federal R&D for Countering Terrorism

In fiscal year (FY) 2002, the Federal Government appropriated $44.4 billion for combating terrorism, $1.2 billion of which was R&D funding. As a point of reference, the total Federal budget for R&D activities to develop technologies to deter, prevent, or mitigate terrorist acts was less than half this amount ($511 million) in FY 2000. As figure 7 indicates, a large portion of the FY 2002 counterterrorism R&D was funded by the Department of Defense (DOD), most notably the Defense Advanced Research Projects Agency. The National Science Foundation was the next largest source of funds with over $200 million in research aimed at protecting critical infrastructure and key assets. The various agencies and offices that now constitute the Department of Homeland Security (DHS) had a combined R&D budget for combating terrorism of $200 million in FY 2002. Numerous other agencies, ranging from the Department of Health and Human Services (HHS) to the Department of Justice, supported counterterrorism R&D in FY 2002.

The Federal budget for counterterrorism R&D grew to almost $2.7 billion in the enacted FY 2003 budget. Almost a third of this R&D ($830 million) was requested for HHS, specifically for bioterrorism-related R&D at the National Institutes of Health (NIH). The budget for counterterrorism R&D programs in the agencies now within DHS more than tripled to $660 million. Counterterrorism R&D funded by DOD, with an emphasis on R&D to support war-fighting applications and counterbioterrorism, more than doubled in the FY 2003 budget.

Although the FY 2004 budget has not yet been enacted, the 225 percent increase in the budget for counterterrorism R&D between FY 2002 and FY 2003 appears to have been a one-time event. The FY 2004 budget proposes further increases in Federal R&D investment in the priority area of homeland security, particularly research against bioterrorism at NIH. However, the most prominent change from the FY 2003 budget is organizational rather than monetary. On January 24, 2003, DHS was officially established and the R&D programs of several agencies were consolidated under its management. The President's budget request reflects this consolidation and calls for a $1.0 billion R&D budget for the new department. Analysis by the Office of Management and Budget reports that $844 million of this amount is focused on R&D to combat terrorism, a fourfold increase over the enacted FY 2002 budget.

FIGURE 7. Federal research and development budget for combating terrorism, by agency: FY 2002 and 2003
(Millions of dollars)



DHS Department of Homeland Security component agencies; DOD Department of Defense; DOJ Department of Justice; HHS Department of Health and Human Services; NSF National Science Foundation

SOURCE: U.S. Office of Management and Budget, *Annual Report to Congress on Combating Terrorism* (Washington, DC, 2003).

TABLE 2. Budget authority for research and development, by Federal agency and character of work, proposed levels: FY 2004

Agency	Character of work (millions of dollars)				Percent R&D as share of discretionary budget
	R&D total	Basic research	Applied research and development	Discretionary budget authority	
All Federal Government	118,014	26,862	91,152	782,219	15.1
Department of Defense	62,672	1,309	61,363	379,898	16.5
Health and Human Services	28,108	14,804	13,304	66,195	42.5
National Institutes of Health	26,866	14,801	12,065	27,742	96.8
National Aeronautics and Space Administration	8,543	2,535	6,008	15,469	55.2
Department of Energy	7,559	2,593	4,966	23,376	32.3
National Science Foundation	3,690	3,486	204	5,481	67.3
Department of Agriculture	1,803	819	984	19,503	9.2
Department of Commerce	1,006	391	615	5,406	18.6
National Oceanic and Atmospheric Administration	675	312	363	3,325	20.3
National Institute for Standards and Technology	318	79	239	498	63.9
Department of the Interior	633	38	595	10,587	6.0
Department of Transportation	674	37	637	13,673	4.9
Environmental Protection Agency	607	90	517	7,627	8.0
Department of Veterans Affairs	822	495	327	28,057	2.9
Department of Education	275	1	274	53,137	0.5
Department of Homeland Security	836	47	789	26,697	3.1
International assistance programs	306	58	248	17,039	1.8
Smithsonian Institution	121	121	0	567	21.3
Tennessee Valley Authority	25	NA	25	NA	NA
Department of Labor	10	2	8	11,535	0.1
Nuclear Regulatory Commission	60	NA	60	626	9.6
Corps of Engineers	27	3	24	4,049	0.7
Department of Housing and Urban Development	51	NA	51	31,301	0.2
Department of Justice	106	33	73	17,697	0.6
Social Security Administration	30	NA	30	3,084	1.0
Postal Service	47	NA	47	NA	NA
Department of the Treasury	3	NA	3	11,397	0.0

NA not available

R&D research and development

NOTE: Details will not add to totals for discretionary budget authority because only R&D funding agencies are listed.

SOURCES: Intersociety Working Group, *AAAS Report XXVIII: Research and Development FY 2004* (Washington, DC, 2003); and U.S. Office of Management and Budget, *Budget of the United States Government, Fiscal Year 2004* (Washington, DC, 2003).

can support R&D programs with the same basic objective, it is useful to aggregate Federal R&D into budget functions to assess broad trends in national R&D priorities.

Space-related R&D as a percentage of total R&D reached a peak of 20.9 percent in 1965, during the height of the nation's efforts to surpass the Soviet Union in space exploration (figure 5). In terms of the nation's R&D performance, space-related R&D accounted for a projected 2.6 percent of total R&D in 2003.[10] The loss of the Space Shuttle Columbia and its crew of seven on February 1, 2003, has resulted in uncertainty as to the future focus and intensity of manned missions in the U.S. space-related R&D effort. In the President's FY 2004 budget, crafted before the disaster, 55.2 percent of NASA's $15.5 billion discretionary budget was reserved for R&D.

The most dramatic change in Federal R&D priorities over the past 20 years has been the growing importance of health-related R&D. As illustrated in figure 6, health-related R&D rose from representing roughly a fourth (27.6 percent) of the Federal nondefense R&D budget allocation in FY 1982 to more than half (54.5 percent) by FY 2003. Most of this growth occurred after 1998, when NIH's budget was set on a pace to double by 2003 (Meeks 2002).

In contrast to the steep growth in health-related R&D, the budget allocation for general science R&D has grown

[10]The steep drop in space-related R&D in fiscal year 2000, as depicted in figure 6, was the result of the National Aeronautics and Space Administration's reclassifying space station R&D to R&D plant.

relatively little in the past 20 years. In fact, the growth in general science R&D (figure 6) is more the result of a reclassification of several Department of Energy (DOE) programs from energy to general science in FY 1998 than the result of increased budget allocations. The formation of the Department of Homeland Security and the coincident reclassification of much of its formerly civilian R&D activities as defense R&D is a more recent example of how R&D budget function classifications can change when the mission or focus of funding agencies changes.

Federal R&D Funding by Performer and Field of Science or Engineering

Federal Funding to Academia. The Federal Government has long provided the largest share of R&D funds used by universities and colleges. In the early 1980s, Federal funds accounted for roughly two-thirds of the academic total. That share dropped to 57.7 percent in 2000 but is projected to rise to 60.8 percent in 2003. Although this share of funding has not changed much in recent years, the actual amount of funding in real terms increased on average 5.1 percent per year between 1985 and 1994, 3.4 percent per year between 1994 and 2000, and 9.8 percent per year between 2000 and 2003.

Federal Funding to Industry. The greatest fluctuation in Federal support as reported by R&D performers occurred in obligations to industry, ranging from a low of $10.4 billion (constant 1996 dollars) in 1955 (when the NSF time series began) to a high of $37.1 billion in 1987 (figure 8). Between 1998 and 2003, Federal funds for industrial R&D activities declined an annual average of 6.3 percent in real terms. Overall, the share of industry's R&D performance funded by the Federal Government has been steadily declining since its peak of 56.7 percent in 1959.[11]

The industries that report the greatest amount of Federal R&D funding include the computer and electronic products industry; the professional, scientific, and technical services industry; and the aerospace industry. Companies in these three industries accounted for 87 percent of all federally funded industrial R&D reported in 2001. In contrast, this same group accounted for only 37 percent of all company-financed R&D in 2001. Approximately half of the $7.9 billion of R&D performed by companies classified in the aerospace industry came from Federal sources in 2001. In comparison, companies classified in the pharmaceuticals and medicines industry reported no federally funded R&D in 2001, although they did and continue to benefit indirectly from the considerable amount of biomedical R&D funded by the Federal Government.

Federal Research Funding by Field

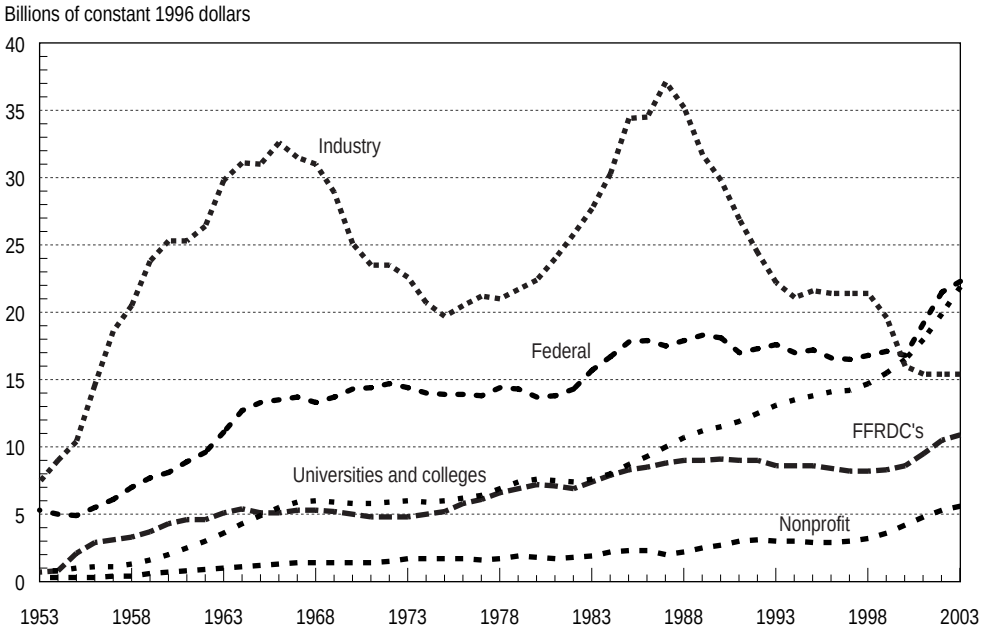
According to preliminary estimates, Federal obligations for research alone (excluding development) totaled $53.4 billion in FY 2003. Life sciences received the largest portion of this funding (53.7 percent, or $28.7 billion), most of which were provided by the Department of Health and Human Services (HHS), followed by engineering (17.2 percent), physical sciences (9.7 percent), environmental sciences (7.3 percent), and mathematics and computer sciences (5.4 percent) (figure 10). Social sciences, psychology, and all other sciences accounted for another 2.0, 1.8, and 3.0 percent, respectively.

HHS, primarily through NIH, provided the largest share (50.2 percent) of all Federal research obligations in FY 2003. The next largest contributor was the Department of Defense (DOD) (12.2 percent), providing substantial funding for research in engineering ($3.3 billion) and in mathematics and computer sciences ($1.1 billion). NASA provided 10.8 percent, primarily in the fields of engineering, environmental sciences, and physical sciences. DOE provided 10.1 percent, primarily in the fields of physical sciences and engineering. NSF provided 6.4 percent, contributing between $0.5 and $0.6 billion to each of the following fields: physical sciences, mathematics and computer sciences, engineering, environmental sciences, and life sciences.

Federal obligations for research have grown at different rates for different science and engineering (S&E) fields, reflecting changes in perceived public needs in those fields, changes in the national resources (e.g., scientists, equipment, and facilities) that have been built up in those fields over time, as well as differences in scientific opportunities across fields (appendix table B-14). Based on preliminary estimates for FY 2003, the major field of mathematics and computer sciences has experienced the highest rate of growth in Federal obligations for research, which was 7.8 percent per year

[11]Beginning in 1989, the amount of federally funded R&D reported by industry began to diverge from the amount reported by the Federal Government. For details on this discrepancy, see sidebar, "Tracking R&D: Gap Between Performer- and Source-Reported Expenditures." Detailed R&D data by source and performer for years prior to 1993 can be found in the online version of this report in table D.

FIGURE 8. Federal research and development support, by performing sector: 1953–2003



FFRDC federally funded research and development center

NOTES: Expenditures of industry FFRDCs for 1953–54 are included in industry. Expenditures of nonprofit FFRDCs for 1953–54 are included in nonprofit.

SOURCE: National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources,* annual series. See appendix table B-1.

Tracking R&D: Gap Between Performer- and Source-Reported Expenditures

In many Organisation for Economic Co-operation and Development (OECD) countries, including the United States, total government R&D support figures reported by government agencies differ substantially from those reported by performers of R&D work. Consistent with international guidance and standards, most countries' national R&D expenditure totals and time series are based primarily on data reported by performers. This convention is preferred because performers are in the best position to indicate how much they spent conducting R&D in a given year and to identify the source of their funds. Although funding and performing series may be expected to differ for many reasons such as different bases used for reporting government obligations (fiscal year) and performance expenditures (calendar year), the gap between the two R&D series creates analytical challenges.

For the United States the reporting gap has become particularly acute over the past several years. In the mid-1980s performer-reported Federal R&D exceeded Federal reports by $3 billion to $4 billion annually (5–10 percent of the government total). This pattern reversed itself toward the end of the decade; in 1989 the government-reported R&D total exceeded performer reports by $1 billion. The gap subsequently grew to almost $13 billion by 2002. In other words, approximately 13 percent of the government total in 2002 was unaccounted for in performer surveys (figure 9). The difference in Federal R&D totals was primarily in DOD development funding of industry. For 2002, Federal agencies reported $34.2 billion in total R&D obligations to industrial performers, compared with $17.1 billion in Federal funding reported by industrial performers. Overall, industrywide estimates equal a 50 percent paper

Tracking R&D: Gap Between Performer- and Source-Reported Expenditures (Continued)

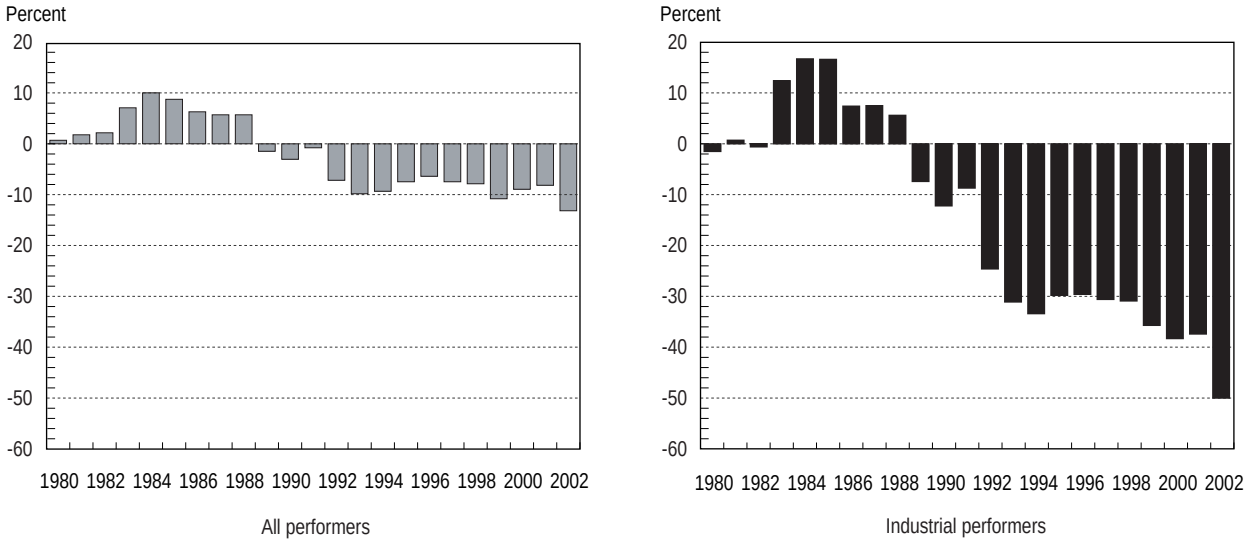
"loss" of federally reported 2002 R&D support (figure 9).

NSF has sponsored ongoing research and investigations into the possible causes for the data gap. Past studies have focused on the following aspects of the phenomenon:

- The relative prominence of similar divergences in the series in countries with large defense R&D expenditures
- Industry interpretations and financial treatment of Federal (particularly defense-related) R&D contracts
- Federal agency R&D data collection and reporting procedures

Each investigation resulted in useful insights into the issue, but conclusive explanations have yet to be identified. According to a U.S. General Accounting Office (GAO 2001, p. 2) investigation, "Because the gap is the result of comparing two dissimilar types of financial data [Federal obligations and performer expenditures], it does not necessarily reflect poor quality data, nor does it reflect whether performers are receiving or spending all the Federal R&D funds obligated to them. Thus, even if the data collection and reporting issues were addressed, a gap would still exist."

FIGURE 9. Difference in U.S. performer-reported and agency-reported Federal research and development: 1980–2002



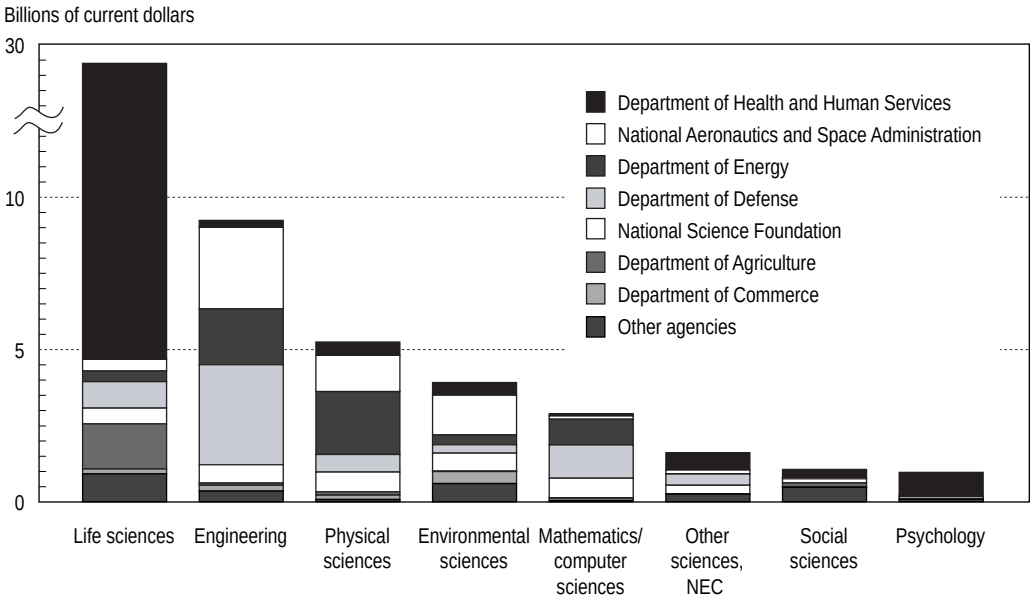
NOTE: Difference is defined as percentage of federally reported research and development (R&D), with a positive difference indicating that performer-reported R&D exceeds agency-reported R&D.

SOURCES: National Science Foundation, Division of Science Resources Statistics (NSF/SRS), special tabulations, 2003; and NSF/SRS, *Federal Funds for Research and Development: Fiscal Years 2001, 2002, and 2003* (Arlington, VA, forthcoming).

in real terms between FY 1982 and FY 2003. Life sciences had the second highest rate (6.2 percent), followed by psychology (4.6 percent); environmental sciences (3.3 percent); social sciences, including anthropology, economics, political sciences, sociology, and other areas (2.3 percent); engineering (2.2 percent); and physical sciences (1.0 percent).

The trends in Federal support for these broad fields of research, however, may not reflect trends for the smaller fields that they contain. For example, within the broad field of mathematics and computer sciences, Federal support for research in mathematics grew 3.3 percent per year in real terms between FY 1982 and FY 2001, whereas support for research in computer

FIGURE 10. Federal obligations for research, by agency and major science and engineering field: FY 2003



NEC not elsewhere classified

SOURCE: National Science Foundation, Division of Science Resources Statistics, *Federal Funds for Research and Development: Fiscal Years 2001, 2002, and 2003,* forthcoming. See appendix table B-14.

sciences grew 10.9 percent per year.[12] Within life sciences during the same period, support for biological and agricultural research grew 6.0 percent per year, compared with research support for medical sciences, which grew 4.3 percent per year. Within the physical sciences, support for astronomy grew 2.7 percent per year, whereas support for physics declined 0.5 percent per year.

Caution should be employed when examining these trends in Federal support for detailed S&E fields because Federal agencies classify a significant amount of R&D only by major S&E field such as life sciences, physical sciences, or social sciences. In FY 2001, for example, 16.6 percent of the Federal research obligations classified by major S&E field were not subdivided into detailed fields. This was less pronounced in physical sciences and in mathematics and computer sciences, in which all but 7.6 percent of the research dollars were subdivided. It was most pronounced in engineering and social sciences, in which 27.3 and 63.9 percent, respectively, of the research obligations were not subdivided into detailed fields.

R&D BY FEDERAL AGENCY

The Federal agencies with the largest R&D expenditures vary considerably in terms of how their R&D budgets are spent.[13] Agency-reported data reveal remarkable diversity in terms of the character of the R&D, who performs the R&D, and how R&D is allocated to performers. These differences reflect the diverse missions, histories, and cultures of the agencies.

DOD. According to preliminary data provided by DOD before budget developments brought about by the war in Iraq, DOD obligated $45.0 billion, more than any other Federal agency, for R&D support in FY 2003. DOD's support represented 45.6 percent of all Federal R&D obligations. More than 85 percent of these funds ($38.5 billion) were spent on development, with

[12]For these subfields, the latest available data are for FY 2001.

[13]The data reported here on expected R&D obligations in FY 2003 were collected before recent budget negotiations and the formation of the Department of Homeland Security. See sidebar "Federal R&D for Countering Terrorism" for data on these recent developments.

$33.0 billion slated for major systems development.[14] Industrial firms are expected to have performed 65 percent of DOD-funded R&D in FY 2003. These firms accounted for an even greater share of development funds (71 percent). DOD's R&D obligations constituted more than 80 percent of all Federal R&D obligations to industry in FY 2003. Of DOD-funded R&D not performed by industry, government agencies and FFRDCs are expected to have performed 85 percent ($13.3 billion).

HHS. HHS, the primary source of Federal health-related R&D funding (largely through NIH), obligated the second largest amount for R&D in FY 2003 at $27.6 billion, most of which ($14.5 billion) was for basic research. In FY 2003 HHS is expected to have provided universities and colleges, the primary recipients of HHS funding, with $15.5 billion, or 67.4 percent, of all Federal R&D funds obligated to universities and colleges (table 3). HHS provided 75.6 percent ($4.7 billion) of all Federal R&D funds obligated to nonprofit institutions, with most of these funds going to large research hospitals such as Massachusetts General Hospital and the Dana-Farber Cancer Institute (NSF, 2002b).

NASA. The third largest agency in terms of R&D support is NASA, with R&D obligations expected to total $8.6 billion in FY 2003; 28.6 percent ($2.5 billion) was earmarked for basic research. Although not defense related, much of the development work sponsored by NASA relies on industrial performers similar to those funded by DOD. NASA is the second largest source of industrial R&D funds, an estimated $3.6 billion in FY 2003. Roughly 82 percent of NASA-funded R&D is performed either by industrial firms or in Federal agencies or FFRDCs. Academic and nonprofit institutions perform the remainder.

DOE. Of the large R&D-funding agencies, DOE relies the most on the R&D capabilities of FFRDCs, obligating 61.1 percent of its estimated $7.5 billion in FY 2003 R&D funding to FFRDCs. DOE is the largest funding source of the 36 FFRDCs, accounting for 61.2 percent of all Federal R&D obligations to FFRDCs in FY 2003.

NSF. NSF is the Federal Government's primary source of funding for general S&E R&D and is estimated to have funded $3.4 billion in R&D in FY 2003. Of these funds, 94.2 percent were for basic research. NSF is the second largest Federal source of R&D funds to universities and colleges and is expected to have provided $2.8 billion to academic researchers in FY 2003.

Other Agencies. DOD, HHS, NASA, DOE, and NSF are estimated to account for 93.4 percent of all Federal R&D obligations in FY 2003, with 93.9 percent of basic research, 85.6 percent of applied research, and 97.8 percent of development. Unlike those Federal agencies, the Department of Agriculture, the Department of Commerce, and the Department of the Interior obligate most of their R&D funds to mission-oriented R&D conducted in their own laboratories, which are run by the Agricultural Research Service, the National Institute for Standards and Technology, and the U.S. Geological Survey, respectively.

Trends in Non-Federal R&D Funding

R&D financing from non-Federal sources grew by 7.6 percent per year after inflation between 1980 and 1985, concurrent with gains in Federal R&D spending. This annual growth rate slowed to 3.3 percent between 1985 and 1994 but rose to 8.6 percent during the 1994–2000 period. More recently, between 2000 and 2003, non-Federal sources of R&D funding declined by a projected 1.5 percent per year in real terms.

As previously discussed, most non-Federal R&D support is provided by industry. Of the projected 2003 non-Federal support total ($199 billion), 90.5 percent ($180 billion) was company funded. Industry's share of national R&D funding first surpassed the Federal Government's in 1980, and it has remained higher ever since. From 1980 to 1985, industrial support for R&D, in real dollars, grew at an average annual rate of 7.7 percent. This growth was maintained through both the mild 1980 recession and the more severe 1982 recession (figure 3). Key factors behind increases in industrial R&D included a growing concern with international competition, especially in high-technology industries; the increasing technological sophistication of products, processes, and services; and general growth in defense-related industries such as electronics, aircraft, and missiles. Between 1985 and 1994, growth in R&D funding from industry was slower, averaging 3.1 percent

[14]The Department of Defense reports development obligations in two categories: *advanced technology development,* which is similar in nature to development funded by most other agencies, and *major systems development,* which includes demonstration and validation, engineering and manufacturing development, management and support, and operational systems development for major weapon systems.

TABLE 3. Estimated Federal research and development obligations, by performing sector and agency funding source: FY 2003

Character of work and performer	Total obligations (millions of dollars)	Primary funding source		Secondary funding source	
		Agency	Percent	Agency	Percent
All R&D	98,608	DOD	46	HHS	28
Federal intramural	24,558	DOD	51	HHS	21
Industrial firms	36,411	DOD	81	NASA	10
Industry-administered FFRDCs	1,478	DOE	71	HHS	19
Universities and colleges	23,055	HHS	67	NSF	12
Universities and college FFRDCs	4,835	DOE	58	NASA	29
Other nonprofit organizations	6,261	HHS	76	NASA	9
Nonprofit-administered FFRDCs	1,222	DOE	60	DOD	33
Basic research	25,977	HHS	56	NSF	12
Federal intramural	4,411	HHS	43	USDA	15
Industrial firms	1,446	NASA	38	HHS	31
Industry-administered FFRDCs	220	HHS	76	DOE	24
Universities and colleges	14,024	HHS	65	NSF	19
Universities and college FFRDCs	1,984	DOE	60	NASA	27
Other nonprofit organizations	3,153	HHS	85	NSF	7
Nonprofit-administered FFRDCs	571	DOE	93	HHS	5
Applied research	27,400	HHS	45	DOD	17
Federal intramural	8,799	HHS	37	DOD	22
Industrial firms	5,119	DOD	40	NASA	38
Industry-administered FFRDCs	762	DOE	80	HHS	15
Universities and colleges	8,205	HHS	78	DOD	6
Universities and college FFRDCs	1,494	DOE	87	NASA	5
Other nonprofit organizations	2,598	HHS	75	NASA	8
Nonprofit-administered FFRDCs	171	DOE	57	DOD	22
Development	45,231	DOD	85	NASA	6
Federal intramural	11,347	DOD	86	NASA	6
Industrial firms	29,846	DOD	91	NASA	3
Industry-administered FFRDCs	495	DOE	78	DOD	22
Universities and colleges	826	DOD	60	NASA	16
Universities and college FFRDCs	1,356	NASA	58	DOE	26
Other nonprofit organizations	510	NASA	35	DOD	25
Nonprofit-administered FFRDCs	481	DOD	76	DOE	23

DOD Department of Defense; DOE Department of Energy; FFRDC federally funded research and development center; HHS Department of Health and Human Services; NASA National Aeronautics and Space Administration; NSF National Science Foundation; R&D research and development; USDA Department of Agriculture

NOTE: Subtotals by performer do not add to total because state and local governments and foreign performers of R&D are included in the total but not shown separately.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Federal Funds for Research and Development, FY 2001, 2002, and 2003.

per year in real terms, but from 1994 to 2000 industrial R&D support grew in real terms by 8.8 percent per year. This rapid growth rate came to a halt following the downturn in both the market valuation and economic demand for technology in the first years of the 21st century. Between 2000 and 2003 industrial R&D support declined by a projected 2.3 percent per year in real terms.

R&D funding from other non-Federal sectors, namely, academic and other nonprofit institutions and state and local governments, has been more consistent over time, growing at an average annual rate of 6.4 percent between 1980 and 2003 after adjusting for inflation. Most of these funds went to research performed within the academic sector.

Trends in R&D by Character of Work

Because research and development encompasses a broad range of activities, it is helpful to disaggregate R&D expenditures into the traditional categories of basic research, applied research, and development. Despite the difficulties in classifying specific R&D projects, these categories are useful for characterizing the expected time

horizons, outputs, and types of investments associated with R&D expenditures.

In 2003 the United States performed a projected $54.1 billion of basic research, $67.8 billion of applied research, and $161.9 billion of development (table 1). As a share of all 2003 R&D expenditures, basic research represented 19.1 percent, applied research represented 23.9 percent, and development represented 57.1 percent.

Basic Research

In 2003 universities and colleges are projected to have performed 55.3 percent of basic research, more than any other sector (table 1; figure 11). The intellectual freedom and diversity of these institutions make them ideally suited to carry out basic research. Industry performed a projected 14.3 percent of U.S. basic research in 2003. Rather than serve an immediate market need, the basic research performed by a firm with industry funds serves to strengthen the innovative capacity of the firm by developing human capital and increasing the capability of the firm to absorb external scientific and technological knowledge.

The Federal Government has historically provided the majority of funding for basic research and is estimated to have provided 60.5 percent of basic research funding in 2003 (table 1; figure 11). Moreover, the Federal Government funded a projected 63.5 percent of the basic research performed by universities and colleges in 2003. Industry devoted an estimated 5.0 percent of its total R&D support to basic research in 2003, representing 16.7 percent of the national total. The reason for industry's relatively small contribution to basic research is that basic research generally involves the most uncertainty in terms of both the technical success and the commercial value of any of the three broad categories of R&D. The industries that invest the most in basic research are those whose new products and services are most directly linked to advances in science and engineering, such as the pharmaceuticals industry and the scientific R&D services industry.

Applied Research

U.S. applied research, which totaled a projected $67.8 billion in 2003, is performed largely by nonacademic institutions. Industrial performers accounted for 62.6 percent of all applied research, with the remainder largely performed by Federal laboratories and FFRDCs (17.9 percent). Industrial support accounts for 58.4 percent ($39.6 billion) of the 2003 total for applied research, and Federal support accounts for 34.6 percent ($23.5 billion). The Federal Government's investment in research has historically emphasized basic research over applied research, reflecting the belief that the private sector is less likely to invest in basic research. In 2003, Federal funding for applied research was 72 percent of that for basic research (table 1).

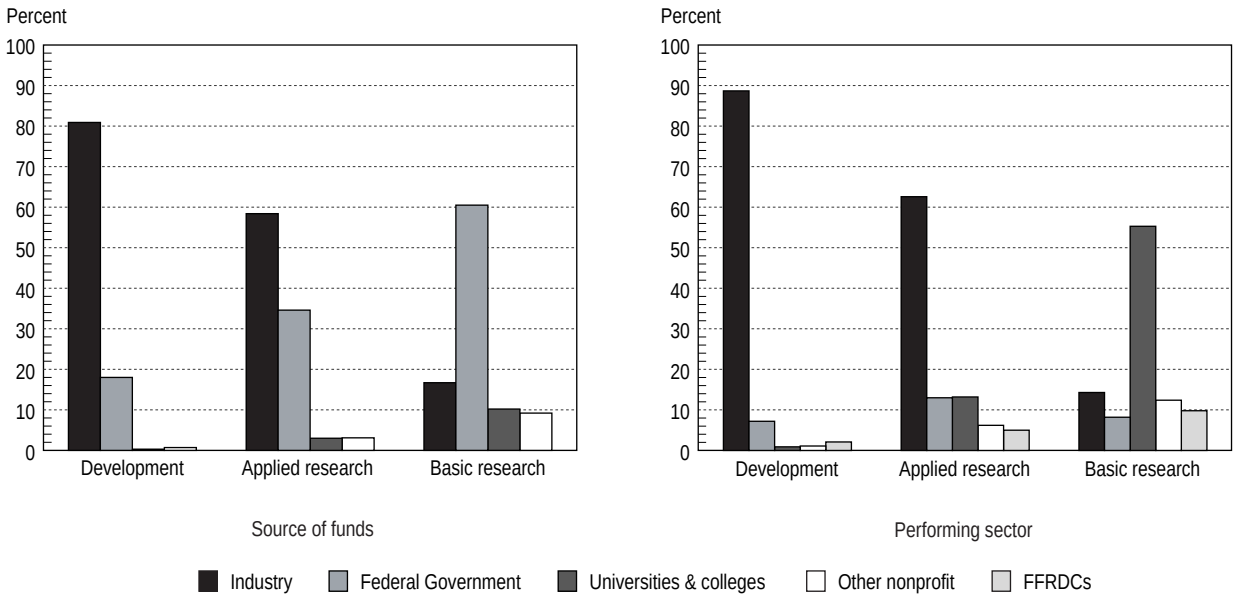
Within industry, applied research acts to refine and adapt existing scientific knowledge and technology into knowledge and techniques useful for creating or improving products, processes, or services. Examples of industries that perform a relatively large amount of applied research are the semiconductor industry and the biotechnology industry.

Development

Development expenditures totaled a projected $161.9 billion in 2003, representing the majority of U.S. R&D expenditures. The development of new and improved goods, services, and processes is dominated by industry, which performed 88.7 percent of all U.S. development in 2003. Federal laboratories and FFRDCs performed an estimated 9.4 percent of U.S. development; the remainder was performed by universities and colleges and nonprofit institutions.

Industry and the Federal Government together funded 98.9 percent of all development in 2003, with industry providing 80.9 percent and the Federal Government providing 18.0 percent (table 1). The Federal Government generally invests in the development of products for which it is the only consumer such as tactical nuclear weapons and space exploration vehicles. The Federal investment in development is dominated by DOD, which invests 85 percent of its R&D funds in development (figure 12).

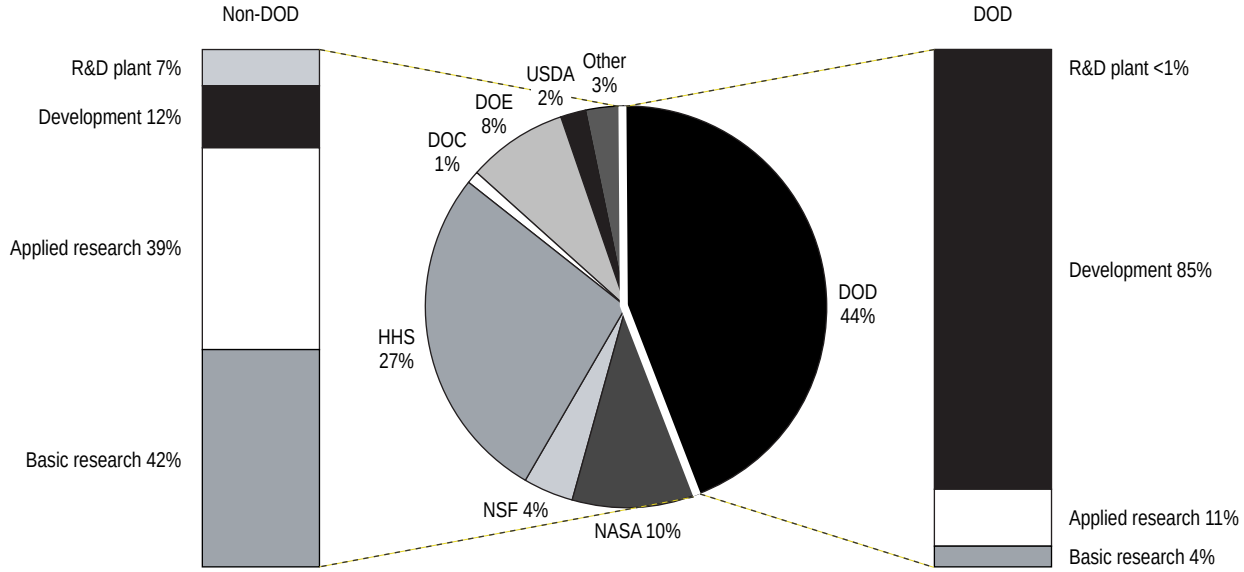
FIGURE 11. U.S. research and development expenditure, by source of funds, performing sector, and character of work: 2003



FFRDC federally funded research and development center

SOURCE: National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources*, annual series.
See appendix tables B-1 through B-8.

FIGURE 12. Projected Federal obligations for research and development and research and development plant, by agency and character of work: FY 2003



DOC Department of Commerce; DOD Department of Defense; DOE Department of Energy; HHS Department of Health and Human Services; NSF National Science Foundation; NASA National Aeronautics and Space Administration; R&D research and development; USDA Department of Agriculture

NOTE: Percents may not sum to 100 because of rounding.

SOURCE: National Science Foundation, Division of Science Resources Statistics, *Federal Funds for Research and Development: Fiscal Years 2001, 2002, and 2003* (Arlington, VA, forthcoming).